THE ROLE OF BARLEY, RYE AND GRASSES IN THE 1973–74 WHEAT STEM RUST EPIPHYTOTIC IN SOUTHERN AND EASTERN AUSTRALIA

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Synopsis

The addition of three further genotypes, namely *Agropyron intermedium* derivative, Entrelargo de Montijo and Barleta Benvenuto, to the Australian wheat stem rust differential set permitted the recognition of 41 strains among 1,530 isolates identified during the 1973–74 wheat season. A comparison is made for each State and region of the stem rust patterns obtained from collections on wheat and those from barley, rye and the grasses *Agropyron scabrum* and *Hordeum leporinum*. The latter patterns reflect to a high degree the relative frequencies of strains well established in the different areas. Population shifts in the pathogen are mainly attributed to factors other than survival ability on grasses. Putative hybrid rusts, probably involving *Puccinia graminis avenae*, are also described.

Introduction

Annual surveys aimed at determining the variability of cereal rusts in Australia have been conducted for more than 50 years and the main emphasis has been placed on the wheat stem rust pathogen, *Puccinia graminis* Pers. f.sp. *tritici* Eriks. and E. Henn. During the last 35 years collections from wheat have comprised two different types, namely those taken from commercial cultivars giving susceptible or semi-resistant reactions to all strains and those coming from cultivars with genes for resistance to certain strains only. On account of the fact that the second group of cultivars placed severe restrictions on the development of some strains having fewer genes for virulence, the tables concerned with relative frequencies are thus biased.

However, such bias is not always caused by collections from wheats in the second group. If it was, the strain pattern obtained only from cultures established from the generally susceptible wheats could be used to give a true picture of the composition of the pathogen population during a particular year. Recently, in Western Australia and South Australia, more than half of the total wheat acreages in each State were sown to one cultivar, Gamenya (*Sr9b*) and Halberd (*Sr6 Sr11*), respectively. These cultivars have genes for resistance which differentiate between strains in those areas and consequently both were important in determining the nature of the rust population in these States.

The 1973 growing season differed in many aspects from previous ones. Stem rust was prevalent throughout the whole of the southern and eastern wheat belts and many samples from wheat were submitted for identification. Also, collections from barley, rye and numerous grasses were made by our, co-operators, as well as by one of us (I.A.W.) during routine survey sampling. The present study exploits this unique opportunity to compare the rust patterns emerging from sampling these different hosts. An attempt is also made to relate the shifts in the *P. g. tritici* population to infection of grasses (possible oversummering), windblown rust movements and cultivars carrying major genes for resistance.

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Materials and Methods

As previously reported (Watson and Luig, 1963) our survey procedure is to take field collections of rusted wheat and to inoculate the susceptible cultivar Sonora W195 with them. The inoculum so increased is then used to infect seedlings of wheat genotypes belonging to four groups. The first group comprises those genotypes of the standard international differential set useful for the Australia-New Zealand geographical region, namely Marquis (*Sr7b*), Reliance (*Sr5*), Mindum, Acme, Einkorn (*Sr21*) and Vernal Emmer (*Sr9e*). The genes in parentheses are important for differentiation. The reactions of these six genotypes determine the standard race number and a further subdivision is made on the basis of the system proposed by Watson and Luig (1963) using eleven supplementary genotypes constituting the second group. The first eight of these and the infection types observed on them have already been described (Watson and Luig, 1963, 1966 ; Luig and Watson, 1970). In 1973 we added W3592, Entrelargo de Montijo W3560 P.I.184525 (a Portuguese *T. durum.* cultivar) and Barleta Benvenuto W3502 C.I.14196 (an Argentine cultivar which possesses a major gene (infection type " X– " to Australian strains)). W3592 is an alien substitution line in which the 7D chromosomes are replaced by a pair of chromosomes from *Agropyron intermedium* (Host) Beauv. This line was derived from an addition line, TAF2 (–W3341) produced by Mme. Y. Cauderon in France. The three additional supplementals have been numbered 9, 10 and 11, respectively.

The third group includes genotypes which combine two or more known genes for resistance, and which are very useful when dealing with mixed cultures. In the fourth group are two varieties (Eagle with *Sr26* derived from *Agropyron elongatum* and Khapstein W1451 with *Sr7a*, *Sr13* and *Sr14*) which have proved resistant to all isolates from this geographical area.

Due to the large number of collections received during the 1973–74 season, many samples which contained sufficient inoculum were first stored at 7°C and low humidity. When differential sets became available, infected stems (or leaves) were cut into short pieces, placed in tubes containing Mobilsol oil and after shaking the spore suspension was used to inoculate seedlings of the four groups of genotypes. This technique reduced the possibility of contamination during inoculum increase.

Rust samples which had their origin on plants other than wheat were dealt with by a different procedure. Samples originating from rye or barley were first applied to Little Club, W2691 and Yalta wheats and to Black Winter rye. In most instances, virulence on rye (3+, 4) and infection types approximating to " X ", " 2= " and " 0 " on W2691, Little Club and Yalta, respectively, were taken as evidence that the particular sample was of rye stem rust *P. g.* f. sp. *secalis* Eriks. and E. Henn. On the other hand, avirulence on rye (;,1,2), infection types " 2= " or " 3+ " on Yalta and susceptibility on W2691 and Little Club indicated that *P. g. tritici* was involved. Such cultures were further tested on the four groups as outlined above.

The collections that could not be categorised as *P. g. secalis* or *P. g. tritici* we classified as " scabrum " rust (see Luig and Watson, 1972). In such instances, Black Winter rye was heterogeneous or intermediate in reaction, Yalta was usually highly resistant, and Little Club and W2691 produced higher infection types than with *P. g. secalis*. Stem rusts other than these three probably occurred occasionally on certain rye genotypes (e.g. stem rust of rye grass caused by *Puccinia graminis* f. sp. *lolii* Guyot and Massenot) but no attempt was made to detect them as their presence was considered insignificant for the present study.

Collections from native or cultivated grasses, e.g. rough wheat grass *Agropyron scabrum* Beauv. and barley grass *Hordeum leporinum* Link., were first tested on Little Club wheat, Black Winter rye, Algerian oats, barley (B240), *Lolium temulentum* L. and *Dactylis glomerata* L. Virulence on wheat indicated the presence of *P. g. tritici*, on oats the presence of oat stem rust *P. graminis* f. sp. *avenae* Eriks. and E. Henn., on Black Winter rye the presence of *P. g. secalis* and on *L. temulentum* the presence of stem rust of rye grass *P. g. lolii*. Scabrum rust was identified by the criteria cited above, whereas hybird rusts (probably involving oat stem rust) were characterised by intermediate infection types on Algerian oats and virulence on *D. glomerata*. The pathogen involved in stem rust of cocksfoot, *P. graminis* f. sp. *dactylidis* Guyot and Massenot, was identified by its virulence on *D. glomerata* and avirulence on the genotypes of the other species.

The locations where collections from the grasses were made are indicated in Fig. 1.

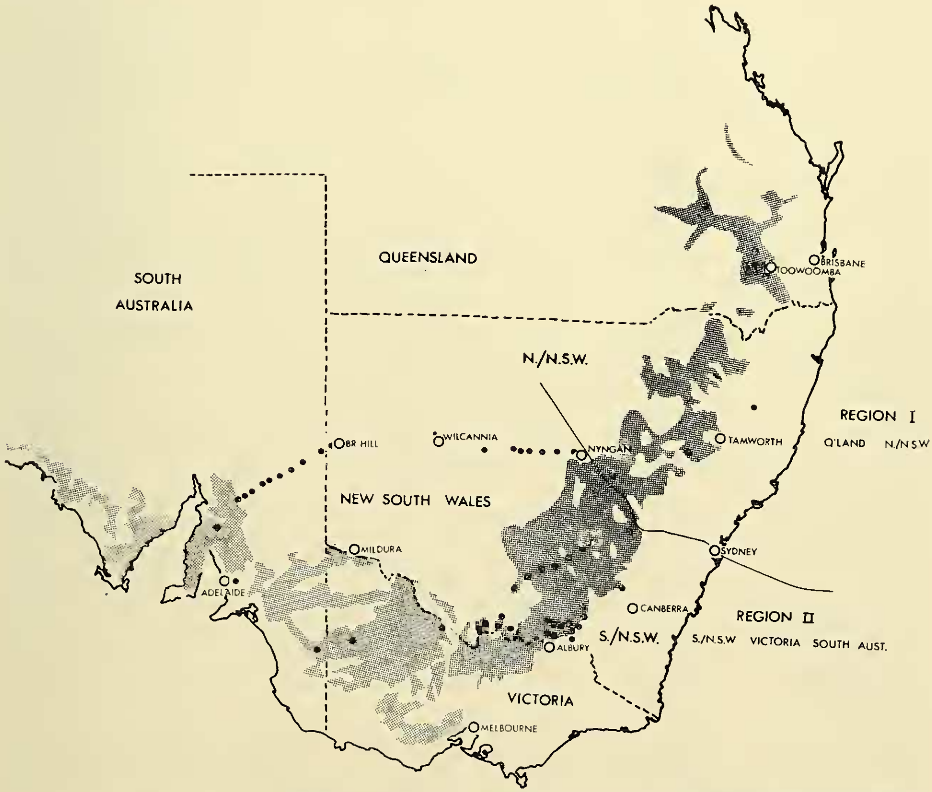

Fig. 1. Sites (•) in Queensland and Northern New South Wales (Region I) and in Southern New South Wales, Victoria and South Australia (Region II) where rusts were collected on grasses.

Results

The main purpose of this study is to compare the patterns in stem rust strains originating from collections made from wheat with those from rye, barley and the grasses and to relate the prevalence of individual strains of wheat stem rust to oversummering (on grasses and volunteer wheat), to rust movements due to windblown inoculum and to wheat cultivars grown in the different areas of the southern and eastern wheat belt. In this connection each State and region (see Luig and Watson, 1970) will be treated *seriatim*. Thus the results from northern and southern New South Wales appear seperately. Table 1 summarises the entire data obtained for the 1973–1974 season.

Summary of the number of isolations of different strains of P. graminis tri

Origin of samples	21–2	–5	–9	–1,2	–2,5	–2,7	–1,2,5	–1,2,6	–1,2,7	–2,3,7	–2,4,5	–2,5,10	–1,2,3,7	–2,3,5,7	–2,3,6,7	–2,3,7,11	–2,5,7,10	–2,3,4,5,7	–2,3,7,8,9
QUEENSLAND																			
fr Wheat	7	27	2	2	12	1				6	1	1						9	7
fr *A. scabrum*	5				1	1													1
fr *H. leporinum*																			
fr Barley	1	1								1									
fr Rye																			
Total	13	28	2	2	13	2				7	1	1						9	8
NORTHERN NEW SOUTH WALES																			
fr Wheat	6	4		2	11		1			5			1					3	3
fr *H. leporinum*					1														1
fr Barley	1				1														
Total	7	4		2	13		1			5			1					3	4
SOUTHERN NEW SOUTH WALES																			
fr Wheat	42	3		47	99	2	3		1	50	1	1		1	1	1	1	4	10
fr *A. scabrum*	3			4	11					1		1			2				
fr *H. leporinum*	3			3	2					6									1
fr Barley	1			1	8					3									2
fr Rye	1									1									
Total	50	3		55	120	2	3		1	61	1	2		1	3	1	1	4	13
VICTORIA																			
fr Wheat	4	1		32	6			1		1									
fr *H. leporinum*										1									
Total	4	1		32	6			1		2									
SOUTH AUSTRALIA																			
fr Wheat	9	1		135	25	3	1		2	19			2		2	1			3
fr *A. scabrum*																			
fr *H. leporinum*	1			6	1	1													
fr Barley	1			13	4					5									
fr Rye																			
Total	11	1		154	30	4	1		2	24			2		2	1			3
WESTERN AUSTRALIA																			
fr Wheat				1															
TASMANIA																			
fr Wheat	1					6													
NEW ZEALAND (NORTH ISLAND)																			
fr Wheat			1							2									
NEW ZEALAND (SOUTH ISLAND)																			
fr Wheat																			
Grand Total	86	37	3	246	188	8	5	1	3	101	2	3	3	1	5	2	1	16	28

…ae speciales *of* P. graminis *during 1973–74 grouped according to their origin*

–2,7	–2,11	–2,3,7	–2,5,7	–2,5,11	–2,7,11	–2,4,5,11	194–1,2	–2,5	–2,3,7	–2,5,7	–1,2,3,5,6	–2,3,7,8,9	–1,2,3,7,8,9	–2,3,7,8,9,10	222–1,2,3,5,6	326–1,2,3,5,6	343–1,2,3,5,6	*P. g. tritici* Total	"Scabrum" rust	*P. gr. avenae*	*P. gr. secalis*	*P. gr. lolii*	Grand Total
		6		2							5	41	14			6		158					158
						1						3	3		2	3		20	3				23
																				1			1
												3						6	2				8
																			1		1		2
		6		2		1					5	47	17		2	9		184	6	1	1		192
	1	3						1		1	3	27	14			30		124					124
																		2		1			3
												1						5					5
	1	3						1		1	3	28	14			30		131		1			132
5	9	134			1				1		7	79	2	1		14		601					601
1	2	10						1				4						49			4		53
1		3	1									3						30		5	3	1	39
		3									1	4				2		35					35
		1																3			6		9
7	11	151	1		1			1	1		8	90	2	1		16		718		5	13	1	737
4	1	5		2							1	2				5		89					89
																	1	3		1			4
4	1	5		2							1	2				5	1	92		1			93
1	3	28		1			12	1				9				29		322					322
																		1					1
			1				1											13					13
		7					2									1		39					39
																					2		2
1	3	35	1	1			15	1				9				30		375			2		377
																		1					1
		3		1												2		22					22
																		3					3
																2		4					4
12	16	203	2	6	1	1	15	3	1	1	17	176	33	1	2	94	1	1530	6	8	16	1	1561

QUEENSLAND (REGION I)

Altogether one hundred and eighty-four identifications of *P. g. tritici* from this area were made and strain 194–2,3,7,8,9 was most prevalent (22·8%). In contrast to the season 1972–73, when virulence on plants with *Sr6* was not detected, 23·3% of the isolates in 1973–74 proved virulent on plants with this gene.

Of eight isolates originating from barley, two were identified as scabrum rust which is a putative hybrid between *P. g. tritici* and *P. g. secalis* (Luig and Watson, 1972) and appears to be pathogenic on commercial barley. The other six isolates were classified as wheat stem rust: three were identified as 194–2,3,7,8,9 and three represented the old, well documented strains 21–2, 21–5 and 21–2,3,7. Since only eight identifications were made, the absence of strains attacking plants with *Sr6* was not significant. On the other hand, sampling from barley had produced a rust pattern more resembling that of 1972–73 than that of 1973–74.

Two samples from rye were collected from the Hermitage Plant Breeding Station, Warwick. One, received early in the season, was identified as scabrum rust, suggesting that susceptible genotypes of rye were infected with inoculum originating on *A. scabrum*. The other, collected later, proved to be *P. g. secalis*.

Of isolates found growing on grasses, 23 came from *A. scabrum* and one from *H. leporinum*. Here the rust pattern was different from that shown when barley was the host. Strain 194–2,3,7,8,9 was detected only in three instances, but eight isolates were of the recently discovered strains possessing virulence on plants with *Sr6* (3×194–1,2,3,7,8,9 ; 3×326–1,2,3,5,6 ; 2×222–1, 2,3,5,6). Strain 222–1,2,3,5,6 came from two sites, Brookstead and Southbrook, separated by only 32 km, and because of virulence on plants with *Sr6* we regard it as possible that the *A. scabrum* A type plants in these areas (Rees, 1972*b*) were infected by inoculum originating on nearby wheats with *Sr6* such as Oxley, Gamut and Tarsa.

Two very rare strains, 34–2,4,5,11 and 21–2,7, were detected among the *A. scabrum* isolates. Unexpectedly, scabrum rust was found only three times. Strains 21–2 (5×), 21–2,3,7,8,9 (1×) and 21–2,5 (1×) accounted for the remainder of the twenty-three samples.

The single sample from *H. leporinum* proved to be *P. graminis avenae*. This shows that barley grass may also be infected by *P. graminis avenae* as well as by *P. graminis tritici*, *P. graminis secalis*, scabrum rust and *P. graminis lolii*. Hence it appears to be a congenial host for several cereal and related *formae speciales* of *P. graminis*.

NORTHERN NEW SOUTH WALES (REGION I)

The strain pattern emerging in northern New South Wales reflected the strong influence that Tarsa and Gamut had on the composition of the rust population in this region. The total area sown to them was relatively small but almost all the remaining area was sown to cultivars with resistance to all strains, e.g. Timgalen, Gatcher and Eagle. There was a small area of Festiguay as well and this accounted for the presence of 194–2,3,7,8,9. Since Tarsa and Gamut each have *Sr6* and *Sr9b* there was strong selection pressure favouring strains with corresponding virulence genes.

Strain 326–1,2,3,5,6, previously recorded only in South Australia, Victoria and southern New South Wales, was detected in 30 of the 131 identifications (22·9%). Six other strains with virulence on plants carrying *Sr6* (194–1,2, 3,7,8,9, 21–1,2,3,7,8,9, 194–1,2,3,5,6, 21–1,2,3,7, 21–1,2 and 21–1,2,5), all unrecorded in this region during the previous season, accounted for 19·8% of the identifications. Strain 194–2,3,7,8,9, the leading strain of the previous season, was recorded in 21·4% of the cases. Among the remaining isolates 11 further strains including 21–2,5, 21–2, 21–2,3,7 and 34–2 were detected.

From three barley samples four different strains, namely 21–2, 34–2 (×2), 21–2,5 and 194–2,3,7,8,9, were identified. About eighteen years ago, 21–2 was very widespread in this region, but has decreased during the last ten years. The others are common in this region. As with the collections from barley in Queensland, no strains virulent on plants with *Sr6* were recovered.

Two rust samples, one of *Phalaris* sp. and the other of *H. leporinum*, were received. The sample from the latter proved to be a mixture of oat stem rust and wheat stem rust (21–2,5 and 21–2,3,7,8,9). The sample from *Phalaris* sp. was a possible hybrid involving *P. graminis avenae*. The significance of this will be discussed later in conjunction with other putative hybrids.

SOUTHERN NEW SOUTH WALES (REGION II)

Nearly 50% of all stem rust samples had their origin in southern New South Wales, and this was expected in view of the extent of the damage suffered in this part of the wheat belt. However, the relative prevalence of the main strains remained about the same as in the previous season, the percentages being: 34–2,3,7—21·1%; 21–2,5—16·9%; 194–2,3,7,8,9—12·7%; 21–2,3,7—8·6%; 21–2—7·0%. The Summit (*Sr5*), attacking strains 34–2 (10·3%), 34–2,5 (5·9%) and 34–2,7 (1·1%), made up more than 17% of the isolates while strains 21–2,3,7,8,9 (1·8) and 194–1,2,3,5,6 (1·1) which are now common in northern New South Wales, accounted for a further 3%. Twelve strains were recovered on three or less occasions.

Altogether 117 *P. g. tritici* isolates originating from hosts other than wheat were identified. About 30% came from barley, with strains 34–2 and 21–2,5 accounting for more than 50%. This proportion was twice that expected. Strain 34–2,3,7, on the other hand, was relatively infrequent. Strains 326–1,2,3,5,6 and 194–1,2,3,5,6 virulent on plants with *Sr6* and *Sr9b*, were also recovered. Of nine isolates from rye, three were *P. g. graminis* (21–2; 21–2,3,7 and 34–2,3,7) and the other six proved to be *P. g. secalis*, which was also found on barley grass (3×) and rough wheat grass (4×). However, the bulk of the samples from the two grasses were identified as *P. g. tritici*. Strains 21–2,5, 34–2,3,7 and 34–2 were prevalent among 49 isolates from *A. scabrum*, while 21–2,3,7 and 34–2 appeared relatively more frequently among thirty isolates from barley grass. Summarising the results and comparing them with the overall pattern from *P. g. tritici* in southern New South Wales it can be concluded that 34–2 occurred on hosts other than wheat with twice the frequency expected, whereas the frequency of 194–2,3,7,8,9 on both types of hosts was approximately the same. Strain 21–2,5 was very frequent on *A. scabrum* and barley. Unlike the wheat samples, 34–2,3,7 did not show up as the leading strain from grasses. The absence of the new, *Sr6*-attacking strains 326–1,2,3,5,6, 194–1,2,3,5,6, 194–1,2,3,7,8,9 and 21–1,2,3,7,8,9 on barley grass and *A. scabrum* was conspicuous; they were recovered twenty-four times from wheat and three times from barley.

A sample obtained from Wimmera rye grass proved to be *P. graminis lolii*. Collections from grasses other than *A. scabrum*, *H. leporinum* or *Lolium* spp. involved *P. graminis avenae* (*Lamarckia aurea* L. (1×), *Aira cupaniana* Guss. (2×), *Phalaris paradoxa* L. (1×), *Bromus hordeaceus* (1×), *Dactylis glomerata* (1×), *Phalaris* sp. (1×), Silver grass *Vulpia bromoides* (2×), Pigeon grass *Setaria geniculata* var. *pauciseta* Desv. (1×)). From Swamp Wallaby grass *Amphibromus neesii* Steud. and from *Phalaris* sp. putative hybrids involving *P. graminis avenae* were recovered. One sample from *D. glomerata* was identified as *P. graminis dactylidis*. In addition to *P. g. tritici* and *P. g. secalis*, barley grass yielded *P. g. avenae*, *P. coronata* F. and L. (crown rust of oats), and the specialised leaf rust pathogens of barley grass and rye grass.

VICTORIA (REGION II)

The most prevalent strain in Victoria was 21–1,2 (34·8%) and this was determined from ninety-two isolates. In previous years there had only been trace amounts of this strain. The increased acreage of Halberd (*Sr6*, *Sr11*) in north-western Victoria has probably contributed to the build up of 21–1,2 but we believe that the predominance of this strain in South Australia has also been responsible to some extent for the change. The influence of Summit (*Sr5*) is shown by 34–2 and 34–2,5 being also among the prevalent strains in Victoria.

Of three samples of rusted barley grass, one yielded strain 34–2, the second gave a mixture of *P. g. avenae* and *P. g. tritici* (21–2,3,7), and from the third a new, previously unrecorded standard race, 343 (343–1,2,3,5,6), was recovered. Presumably this is a mutant for virulence on plants with *Sr5* from the widespread 326–1,2,3,5,6. Should 343–1,2,3,5,6 become more prevalent, the newly released cultivars Condor, Oxley and Egret will be extremely vulnerable as as they possess little or no resistance to this strain.

SOUTH AUSTRALIA (REGION II)

As a consequence of a severe stem rust epiphytotic many samples from South Australia were analysed. Of the three hundred and seventy-five isolates of wheat stem rust, three hundred and twenty-two originated from wheat, one from *A. scabrum* and fifty-two came from either barley or barley grass. Since Halberd (*Sr6*, *Sr11*) was the leading cultivar in South Australia, it was not surprising to find that strain 21–1,2 was predominant (41·1%). Five strains which are virulent on Halberd, 326–1,2,3,5,6 (8·0%), 194–1,2 (4·0%), 21–1,2,7 (0·5%), 21–1,2,3,7 (0·5%) and 21–1,2,5 (0·3%) were also found. These together with 21–1,2 accounted for 54·4% of the isolates.

TABLE 2

Behaviour of 14 wheat genotypes when tested with strain 34–2,11 and its putative parents SRN 21 and SRN 126

	SRN 126	SRN 21	34–2,11
Stocks with *Sr5*	+	–	+
Stocks with *Sr7a*	+	–	+
Stocks with *Sr10*	+	–	+
Stocks with *Sr12*	–	+	–
Stocks with *SrK*	+	–	+
Stocks with SrL_2	+	–	+
Barleta Benvenuto	+	–	+
Stocks with *Sr6**	–	+	+
Stocks with *Sr8*	+	–	–
Stocks with *Sr14*	–	+	+
Stocks with *Sr15*	+	–	–
Stocks with *Sr17*	+	–	–
Mindum	–	+	+
Acme	–	+	+

+ = virulent — = avirulent * = at temperatures above 20°C

Excluding 194–2,3,7,8,9, eleven strains, recovered at least four times, came from wheat as well as from barley and barley grass. Apart from the northern part of the wheat belt (Region I) where 194–2,3,7,8,9 infects crops of Festiguay carrying Webster type resistance, this strain is mainly found on cultivars with the gene *Sr9b* (Robin, Raven, Gamenya). During previous seasons, 194–2,3, 7,8,9 was virtually nonexistent in the south (Region II) but was found to be very prevalent in the central and northern parts in 1973–74. The absence of

194–2,3,7,8,9 in samples from any alternative grass host is interpreted to indicate that its presence on wheat in South Australia resulted from recent north to south spore movement.

Of the 30 isolates of 326–1,2,3,5,6, 29 were collected on wheat. The exception, the last sample of the season, came from barley. The virtual absence of this strain from hosts other than wheat indicates that the spread of 326–1,2,3,5,6 is mainly promoted by cultivars carrying the genes *Sr6* and/or *Sr9b* (Halberd, Tarsa, Gamut, Robin, Gamenya, Raven). In all other instances, the common strains of South Australia were proportionally well represented in isolates from barley and barley grass.

The recovery of 34–2 twice among the 13 isolates from *H. leporinum* is worthy of comment because this strain has replaced 34–2,11 in the southern regions of the country. Studies of the evolution of the Australian strains of *P. g. tritici* suggest that 34–2 and 34–2,11, although seemingly closely related, have arisen in different ways. The latter was first found in 1957 and, we believe, had its origin as a somatic hybrid between the old standard race number (SRN) 126 of 1925, which was still present, and SRN 21 which became prevalent after 1954 (Luig and Watson, 1970). Strain 34–2,11 has some of the characters of each putative parent as shown by the reactions on seedlings of 14 genotypes in Table 2.

Following the increased acreage sown to Summit (*Sr5*) in Victoria, 21–2, which is a very common strain in the south, mutates at the locus corresponding with *Sr5*, and 34–2 arises. Otherwise 34–2 resembles 21–2. Likewise, strains 21–2,5 and 21–2,7 can give rise to 34–2,5 and 34–2,7, which differ from 34–2,5, 11 and 34–2,7,11 on all genotypes which differentiate between 34–2 and 34–2,11.

As shown in Table 1, the strains which had their origin in the putative somatic hybrid are rare. In mixed cultures their detection on seedlings with *Sr7a*, *Sr10*, *Sr12*, *SrL2* and *SrK* is difficult, as the infection types in each instance are not sufficiently distinct. However, on Barleta Benvenuto they are easily contrasted ("3,3+." vs. ";1++"), and therefore this variety is included as the 11th extra-differential into our stem rust set. This enables us to observe the decline of the older components of race 34 which apparently have not adapted as well to the environment as those developed more recently.

Putative Hybrid Rusts

As reported under northern and southern New South Wales, five putative hybrid rusts resembling avirulent strains of *P. g. avenae* were recovered. One culture, 74044, was from Armidale in northern New South Wales and four were from the Holbrook region in southern New South Wales and separated by less than 75 km. The origins and characteristics of the five cultures are shown in Table 2. While all five were virulent on wild oats (*Avenae fatua* L. and *A. ludoviciana* Durieu) and produced semi-resistant reactions on Algerian oats, their behaviour on Saia oats (*A. strigosa* Schreb.), *Lolium temulentum*, and *Phalaris canariensis* L. showed the presence of four distinct types. Cultures 74078 and 74079 may be similar.

Four of the cultures, 74044, 74059, 74078 and 74079, in producing identical infection types on the 12 Australian Oat Stem Rust Testers, resembled culture 69968 previously described (Luig and Baker, 1973; Luig and Watson, 1972).

Discussion

From the results we have reported it is doubtful whether native and naturalised grasses have a cardinal role in initiating wheat stem rust epiphytotics in the southern and eastern wheat belts. Years of observations of local outbreaks of wheat stem rust have convinced one of us (I.A.W.) that infected volunteer wheat is the salient factor in the persistence and perpetuation of this

TABLE 3

Infection types produced by five grass stem rusts on three naturalised grasses and three species of Avenae

Accession number of rust culture	Locality	Host	Infection type on seedling of					
			Lolium temulentum	*Phalaris canariensis*	*Dactylis glomerata*	Algerian Oats 09**	*A. ludoviciana* 0736**	*A. strigosa* Saia 0589** C.I.7010
74044	Armidale	*Phalaris* sp.	3	3	X,3	1++	3+	3+
74050	Carabost	*Amphibromus nesii*	0	; 1–N	X,3	2	3	; 0
74059	Cookardinia	,,	0	; 1–N	X,3	1++	3+	3+
74078	Table Top	*Phalaris* sp.	0	3	X,3	1++	3+	3+
74079	Little Billagong	*Phalaris* sp.	0*	3	X,3	1++	3+	3+

* one plant gave " 3 " infection type.
** 0 numbers refer to Sydney University Oat Accession Lists.

parasite. The fact that a considerable proportion of rust collected from *A. scabrum* is scabrum rust (Table 1 ; Luig, unpublished) which is non-pathogenic on commercial wheat, decreases the significance of this grass as an initial source of inoculum. This investigation also shows that *H. leporinum* is susceptible to many *formae speciales* as well as to *P. g. tritici.*

Nevertheless, in dry years native grasses could be partially responsible for the overseasoning of the fungus in certain areas, especially Queensland (Rees, 1972*a*). Furthermore, the role of grasses such as *A. scabrum* and *H. leporinum* in epiphytotics of wheat is not limited to the amount of initial inoculum supplied ; the composition of the inoculum could also be influenced by them. Rust populations have to adjust themselves so that they comprise strains best suited to the common genotypes of the grass species essential for their survival, and these strains must also have the necessary genes for virulence, to infect common wheat cultivars carrying simple resistances. A comparison of the strains isolated from collections made in Region I (Queensland and northern New South Wales) showed that 194–2,3,7,8,9 was the most frequent strain in wheat samples but was poorly represented in samples from grasses. Again, the most widespread strains in southern New South Wales, 34–2,3,7 and 21–2,5, were not recovered from *A. scabrum* and *H. leporinum* as frequently as expected. On the other hand, 21–1,2, the most prevalent strain in South Australia and Victoria, was proportionally well represented on grasses while 34–2 was found on grasses more often than expected. Strain 21–2 was common on *A. scabrum* in Queensland. In spite of lacking many factors for virulence, this strain was also recovered frequently from wheat cultivars susceptible to all strains.

The present study further suggests that recently detected strains combining genes for virulence on genotypes with *Sr6* and *Sr9b* (Tarsa and Gamut) were not widespread on grasses. However, as the wheat season progressed, rust isolates from rough wheat grass or barley grass seemed to be a reflection of the epiphytotic rather than its cause. Again, the other alternative hosts of *P. g. tritici*, barley and certain genotypes of commercial rye, when infected during the latter part of the season, appeared to present a strain pattern similar to that expected from wheat cultivars susceptible to all rust strains.

Although stem rust development in the northern part of the eastern wheat belt normally precedes outbreaks in the south, a reverse situation was apparent during 1973–74. While a severe stem rust epiphytotic developed in South Australia, Queensland and northern New South Wales suffered little damage due to a scarcity of inoculum and to the widespread cultivation of resistant wheats. Since some loss was experienced from leaf rust, we believe that susceptible cultivars if widely grown would have been damaged by stem rust. The environment was ideal for long-distance aerial movement of stem rust inoculum and the survey showed that this was happening. During the early growing season, rust collections from Queensland and northern New South Wales comprised old established strains such as 21–5, 21–2,3,4,5,7 and 21–2, 3,7,8,9; later, strains common in central New South Wales (34–2,3,7, 21–2,5, 21–2,3,7, *et al.*) were prominent among the northern isolates ; at the end of the season, a larger proportion of collections came from the previously resistant cultivars Tarsa and Gamut. Many of the isolates collected on these latter were of strains virulent on plants with *Sr6*, which had proved effective against all isolates from these areas in preceding seasons. With the exception of 21–1,2,3,7, 21–1,2,3,7,8,9 and 194–1,2,3,7,8,9, which probably arose as mutants from strains present in the northern part of the wheat belt, the other strains (21–1,2, 21–1,2,5, 194–1,2,3,5,6, 222–1,2,3,5,6 and 326–1,2,3,5,6) had previously been detected in the central and southern part of the wheat belt. This showed that southern strains had established themselves in the north and, in due course, had caused some of the outbreaks of stem rust on Gamut and Tarsa. We also attribute the infection of *A. scabrum* plants in Queensland by strains 326–1, 2,3,5,6, 194–1,2,3,7,8,9 and 222–1,2,3,5,6 to movement of rust inoculum from infected crops to this grass later in the season.

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